Examining the differences in Extreme Precipitation and Convective events and their variation in Bangladesh and Eastern India

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Introduction

Bangladesh and Eastern India are among the rainiest regions during the Asian monsoon. This study reviews mesoscale precipitation features, in particular, the diurnal and seasonal variations of precipitation, rain contribution, and cloud fraction. The Bangladesh region (yellow) is bounded by coordinates of 22.77° to 26.03°N and 88.37° to 92.37°E. The Eastern India region (red) is bounded the coordinates of 24.18° to 29.01°N and 92.78° to 98.78°E (Figure 1).

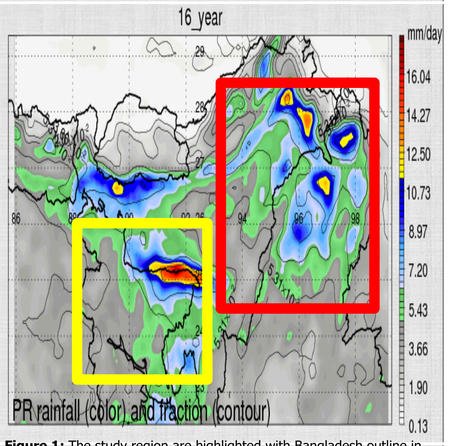

Figure 1: The study region are highlighted with Bangladesh outline in yellow, and Eastern India outlined in red. The annual precipitable rainfall and fraction are averaged from TRMM precipitation radar retrievals over a 16-year period from 1997-2013.

Motivation

Despite both areas receiving a large amount of rain annually, the Eastern India region generally receives more samples of rain events annually, but much less convective events throughout the year than Bangladesh. It is important to understand the differences between the precipitation events and their properties over the two areas.

Hypothesis

Bangladesh has stronger convective events and Eastern India has more precipitation events due to different orographic features and large-scale thermodynamic environments.

Methodology

Over the study regions of Bangladesh and Eastern India, figures are created to show the precipitation variations and contributions from Meso-Scale Convective Systems (MCSs). These differences are plotted against each other. The tables and graphs are from TAMUCC-PMM's Regional Climatology online search tool. Several extreme events are chosen within the study regions using TRMM's MCS observation search tool. One event from each region is examined further, with cross sections and ERA interim environments. The differences are discussed, as well as the meteorological explanations for the climatology and the specific extreme events.

Analysis

The diurnal and seasonal variations, and contributions are evident in the charts and figures below.

- In Bangladesh, the mean annual precipitation is approximately 1930mm/yr, and in Eastern India, it is approximately 2600mm/yr.
- Bangladesh has less precipitation events (peaking in late July) than Eastern India, but have larger mean size and volumetric rain, deeper echo top heights and significantly higher flash counts.
- The thunderstorm events are more frequent in MAM in both regions, prior to monsoon season in JJA. Different from general afternoon peak of precipitation over land, both Bangladesh and Eastern India have similar diurnal variation results, with the peak being early in the morning. (Figure 2)
- Over both regions, MCSs contributed a significant amount of the total rainfall, 77% in Bangladesh and 74 in Eastern Indian. However, there are a lot more MCSs in Eastern Indian that do not have lightning. Thunderstorms over Eastern India only contribute 34% of total rainfall, in contrast to 57% in Bangladesh. (Figure 3)

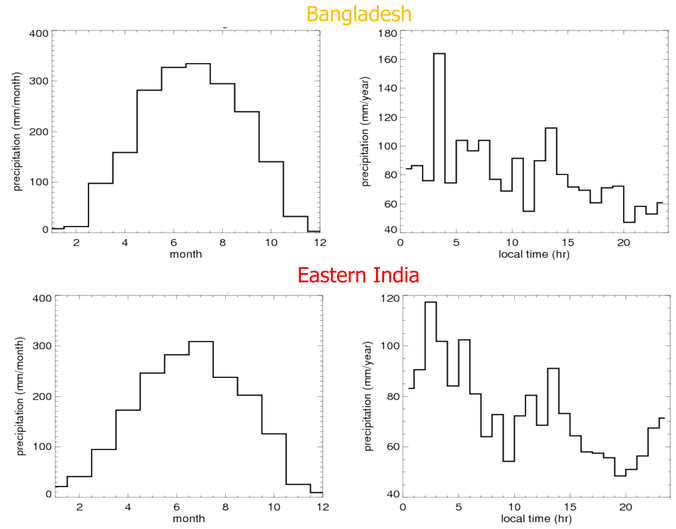

Figure 2: The annual precipitation variation in terms of both monthly and hourly scales, for Bangladesh and Eastern India respectively.

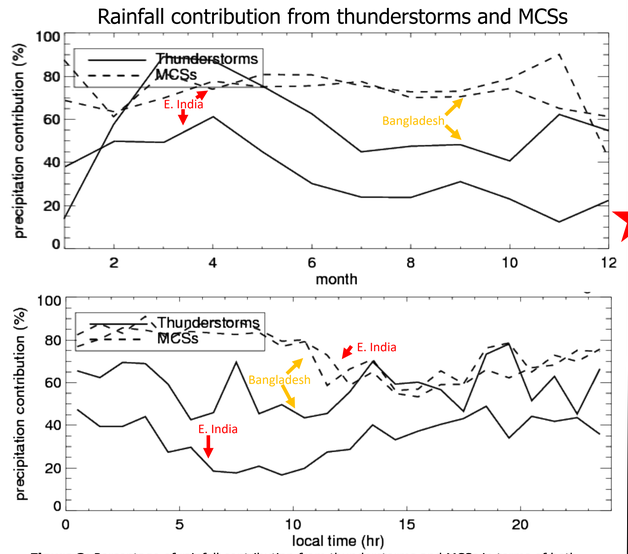

Figure 3: Percentage of rainfall contribution from thunderstorms and MCSs in terms of both monthly and hourly, with Bangladesh and Eastern India being labeled for each line respectively.

		samples (#)	mean size (km^2)	mean volumetric rain ($mm/hr*km^2$)	mean echo top (km)	mean 30 dBZ echo top (km)	mean flash count (#)
Bangladesh	ALL	14527	1062	505	7.0	4.3	1.81
	DJF	354	1078	2480	5.4	2.7	1.03
	MAM	2498	1249	8118	7.8	5.4	7.93
	JJA	8175	979	4402	6.8	4.0	0.49
	SON	3500	1121	4433	7.2	4.4	0.6
Eastern India	ALL	52491	906	2998	6.6	3.4	0.33
	DJF	3390	713	1886	5.4	2.1	0.28
	MAM	12631	1001	3619	6.4	3.3	0.77
	JJA	24385	927	3026	6.8	3.6	0.16
	SON	12085	818	2603	6.6	3.5	0.22

Table 1: The mean properties of precipitation features from both regions, including the annual total and through the months of December-February (DJF), March-May (MAM), June-August (JJA), and September-November (SON).

Extreme Event Discussion

The event in Bangladesh on 5/12/12 was chosen to be further examined due to very high radar echo top levels at different reflectivity levels, which were well above the high-level threshold of 10km. This event had the coldest IR temperature of 171.8K, and the 633 flashes was nearly double of the next highest event. A very large percentage, 96.8% of the event was convective rain. (Table 2) This event had a high volumetric rain, but was smaller than the Indian extreme events. The cross-sections of these events are included to visualize these statistics. (Figures 4-5) The skew-t plot (Figure 7) is very indicative of a high convective event. With a high level of CAPE at 2406 J/kg and intense vertical wind shear, the atmosphere was quite unstable.

The event in Eastern India on 5/14/07 was chosen as despite having low cloud tops, which maxed out at 8km for the 20dBZ reflectivity level, and zero flashes. It had an extremely high volumetric rain, over 200,000 km^2mm/hr. Despite this high value, only a very low portion was convective rain, at 7.4%. (Table 3) This event also occurred near the seasonal and diurnal peaks for this region. The vertical and horizontal cross sections presents itself very differently from Bangladesh, with low, scattered reflectivity, (Figures 8-9) and the skew-t (Figure 11) showing a very saturated sounding, but no indications of convective instability.

Comparing the ERA interims for both events (Figures 6, 10), there are several items to note. Variables T and H are similar for both events. THETA E, which is useful for diagnosing atmospheric instability, has similar values for both events. CAPE and shear values were higher in Bangladesh, indicating a large convective instability. In Eastern India, a strong southerly wind transported the near saturated air onto the V shape mountain slopes and produced a large area of heavy precipitation, due to orographic lifting.

Extreme Events

Several of the rainiest and most significant events are studied, with one from both regions are examined further below.

Bangladesh Extreme Event Statistics

Orbit	Lat	Lon	Date	Time UTC	Volume Rain	MaxHt 20 (km)	MaxHt 30 (km)	MaxHt 40 (km)	Min85 (K)	Min37 (K)	MinIR (K)	Flashes (#)	MaxNSZ (dBZ)	ConvR (%)
25529	24.22	92.19	20020507	21.4	105150	16.2	15.0	10.5	114.5	220.1	195.1	137.0	52.6	72.9
82540	25.22	90.12	20120512	16.5	103351	18.5	18.0	17.0	64.0	124.1	171.8	633.0	55.4	96.8
76999	23.90	90.45	20110523	4.2	222897	18.0	17.0	12.0	70.9	193.3	179.2	165.0	57.0	90.7
76694	25.35	90.36	20110503	14.6	473877	15.8	15.5	14.0	74.6	171.2	190.7	340.0	56.5	98.6

Eastern India Extreme Event Statistics

Orbit	Lat	Lon	Date	Time UTC	Volume Rain	MaxHt 20 (km)	MaxHt 30 (km)	MaxHt 40 (km)	Min85 (K)	Min37 (K)	MinIR (K)	Flashes (#)	MaxNSZ (dBZ)	ConvR (%)
58087	25.24	96.61	20080125	18.8	114027	6.8	4.0	2.8	236.1	260.6	235.1	0.0	58.9	14.0
54088	26.36	95.68	20070514	5.0	200056	8.0	6.0	4.8	235.2	263.6	216.8	0.0	53.4	7.4
45220	27.73	93.78	20051022	5.8	134985	7.8	6.2	4.2	229.6	250.3	220.7	0.0	51.5	23.5

Tables 2-3: The extreme events selected from both regions. Properties include: location, date, time, volumetric rain (mm/hr km^2), maximum 20, 30, 40 dBZ echo top heights, minimum brightness temperature at 85 and 37 GHz and infrared, lightning flash counts, maximum near surface radar reflectivity, and convective rainfall fraction.

Figures 4-7: Examine the Bangladesh extreme event further, with horizontal cross sections overlay with flash, vertical cross sections, ERA interims showing different variables, and the skew-t which shows the sounding and properties of the event.

Figures 8-11: Examines the Eastern India extreme event further, with horizontal cross sections overlay with flash, vertical cross sections, ERA interims showing different variables, and the skew-t which shows the sounding and properties of the event.

Conclusion

Upon examination of the two study areas, there are similarities between the two regions. However, despite being in relative proximity in Southeast Asia, there are a few significant differences within the regions. Both regions receive a large amount of precipitation, but only the Bangladesh region has a large contribution of rain from intense convection. The thunderstorm events are more frequent in MAM, prior to monsoon season in JJA. The MCS diurnal variation peaked in the early morning, as opposed to a general afternoon peak of thunderstorms. Another factor is the winds for the extreme events that are studied. In Bangladesh, varying winds across the area contributed to intense vertical wind shear, which lead to atmospheric instability. Eastern India was starkly different, with a primarily southerly flow. This resulted in saturated air being transported towards the mountain slope nearby the region. The orographic lifting was a result from the Himalayan mountains and Chittagong Hills. Overall, both regions were impacted by geographic feature and meteorological influences that accounted for the extreme event's differences in precipitation and convection.

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